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**CONTENT OF MANGANESE IN SOILS
OF THE ALAKOL HOLLOW**

Abstract. The soils of the Alakol depression are investigated. The physical and chemical properties of brown, meadow-brown and gray-brown soils, meadow saline, sands of ridge-hummocky half-fastened, marshy (flood plain) soils, also the gross content and concentration of the mobile form of manganese (Mn) are considered. The concentration of the elements was studied by profiles of soils. The gross content and concentration of the mobile form of Mn in soils were determined by the atomic absorption method. The statistical processing of the obtained data was carried out by N. A. Plokhinsky using Microsoft Excel. The level of the concentrations of the element under investigation is estimated, and the character of its intra-profile distribution is considered. The coefficients of the correlation dependence of manganese content on the physicochemical properties of soils are calculated. Investigations were carried out to determine the content of total manganese and its exchange form in soil-forming rocks and soils of the Alakol depression, and their ecological and geochemical assessment was given. Specifically, the content and distribution of gross manganese in soils and the correlation dependence on the clay fraction, carbonates, pH of the medium. It was revealed that in the mobile pool of manganese compounds in soils, the share of the mobile form accounts for 10.5% of the gross content. The information obtained on the content and accumulation of manganese reflects the patterns of distribution of Mn in the desert soils of the Alakol depression. Their basic physicochemical properties, the gross content and the exchange (mobile) form of Mn are determined.

Key words: soil, chemical elements, heavy metals, manganese, gross content, exchange form, background content.

Introduction. Soil is a specific component of the biosphere, a poly-phase, multi-component, poly-disperse and poly-functional open system possessing significant buffering due to the aggregation of natural properties including chemical pollution by heavy metals [1]. One of the ecological characteristics of heavy metals is the knowledge of the normal (background) content in soils and parameters of its possible technical genetic pollution. The knowledge of the level of the background content of heavy metals including manganese in soils has a significant practical importance for the development of the strategy of the rational nature use and improvement of the organization of the soil geo-chemical monitoring.

Manganese in plants participates in the breathing process, nitrogen metabolism, protein biosynthesis, and others. In animal organisms, manganese is essential for normal insulin secretion, reproduction, skeletal development, central nervous system functioning and more. According to various researchers data, manganese is a component of more than 10 enzymes that catalyze a variety of metabolic processes [2, 3].

The soil cover of the Alakol hollow is rather different, but the element-chemical structure is studied little and demands the ecological- geochemical research as far as the territory has the economical valuable and recreational significance. The soils of the Alakol hollow are used mainly as the land for pastures and haymaking,

The research objective is to study inside the profile and spatial distribution of manganese and its mobile forms in soils of the Alakol hollow.

Methods. The Alakol hollow occupies the inter-mountainous lake hollow between the mountainous system of Tarbagatay, Barlyk and Zhetysu (Dzhungar) Alatau in the eastern part of Kazakhstan. In the west the hollow is attached the eastern part of Lake Balkhash, in the south-east - to the foundation of Lake Ebinor, situated in China.

The objects of the research are soil-forming rocks and the spreading soils of the Alakol hollow: brown, meadow-brown and grey-brown soils, grey soils (sierozems), meadow saline soils. There were also studied the sands of the bed-lumped, semi-fixed, marshy (flood-marshy) soils situated on the low banks of Lake Alakol. The soil cover of the Alakol hollow is represented mostly by deserted types.

The study of the concentration of the elements was conducted on the profiles of the soils. The content of the gross and the concentration of the mobile form of manganese in the soils were defined by the atomic-absorbing method with the use of the spectrometer «AAC KBAHT-2A». The physical- chemical properties of the soils were defined by the general methods used in soil-studying.

The statistical processing of the received data in the course of the research was conducted with the use of the program of Microsoft Excel on N.A. Plokhinsky [4].

While working up the data there were used the following statistical indices: n - the number of tests; $\bar{x} \pm S\bar{x}$ - medium arithmetic and its mistake; (mg/kg); C_v - coefficient of variation (%); \lim - limits of variations (mg/kg); σ - standard declining (mg/kg); r - coefficient of correlation.

Results and their discussion. The surface of the alluvial plain of the Alakol hollow is composed of: clay, loam, sand and less of crushed stone pebbled material. The foot-hill plain of the ridges of Barlyk and Maily is composed mostly of boulder- pebbled deposits mixed with crushed-stony sands and also in the Alakol hollow there are sands, which are usually composed of the sorted medium- and small grainy quartz-field spar sands.

The manganese content in the parent rock material of the investigated region varies from 189.90 to 664.60 mg/kg. The highest concentration of manganese is found in clay-loam and sandy-loam parent rock materials. Low concentration of manganese is typical for sandy parent rock material.

As the results of the research showed, the average content of humus in the soils of the Alakol hollow in the horizon (A) is 1.52 %; varying within the limits of 0.10- 3.41 %. The content of carbonate in the humus horizons varies within the limits of 0.53-18.55 %. The reaction of the soil solution in the upper horizons is strongly alkaline (pH water within the limits of 8-9.8). The average content of the muddy fraction on the whole profile of the soils is 12.82 % and varies within the limits of 0.16-30.86 %.

The total manganese in soil of humus-accumulative horizon varies from 354.40 to 749.40 mg/kg, in average equal to 500.21 mg/kg. According to health-based exposure limit found average content is 3 times lower and total content is 1500 mg/kg [2].

In soil horizon of Alakol hollow the gross manganese content is evenly distributed. Sands, brown mean clay-loam and gray-brown clay-loam soils achieve the elements content level of parent rock material (diagram).

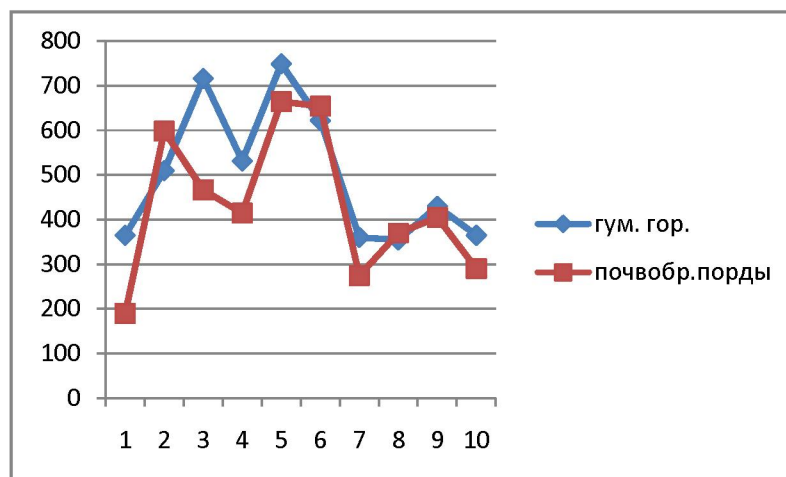
As we see in table 1 the maximal average content of total manganese is typical for meadow-brown sandy-loam soil and minimal average content of total manganese is typical for meadow-brown light-clay-loam soils.

In brown loamy soils down the horizon decreasing of the element content is seen from 716.8 to 465.5 mg/kg, and also is visible an interaction with humus content decreasing. The humus ($r=0.99$) has a great impact on behavior of the element in considered soils.

An average content of manganese in meadow-brown sabulous soils equal to 671.42, and variation coefficient for meadow-brown sandy-loam soil is 6.92%. Correlation relationship with humus is positive and strong ($r=0.83$).

Total manganese content in grey-brown highly skeletal sabulous soils varies from 621.95 to 654.10 mg/kg, variation coefficient - 2.55%, average concentration - 636.77 mg/kg. The element content is decreased down the horizon, a strong invert correlation with humus is seen ($r=-0.99$).

Total manganese content in grey soils varies from 414.6 to 531.40 mg/kg, variation coefficient equal to 12.36%, average concentration - 472.68 mg/kg. A high positive connection with humus is made ($r=0.89$).



Gross manganese content in humus plane (A) and pedogenic stratum plane (C) diagram for Alakol hollow soils:
 1 - Meadow-brown light-loamy soils; 2 - Brown medium-loamy soils; 3 - Brown loamy soils; 4 - Light-loamy grey land;
 5 - Meadow-brown sabulous soils; 6 - Grey-brown highly skeletal sabulous soils; 7 - Overflow-marsh soils;
 8 - Ringe-uneven half-durable sands; 9 - Sands desert-steppe durable; 10 - Meadow heavy heavy sabulous saline soils.
 The average content and the limits of varying of manganese in the soil cover of the studied territories are presented in table 1

Table 1 – Content of gross manganese in soil cover of the Alakol hollow

#	Soils	n	lim	$\bar{x} \pm S\bar{x}$	σ	C _v , %
			mg/kg			
1	Meadow-brown light-loamy soils	5	169,9-364,55	265,77±37,60	84,23	31,69
2	Brown medium-loamy soils	5	309,6-598,40	480,31±56,97	127,61	26,57
3	Brown loamy soils	5	466,5-716,80	591,32±49,55	110,99	18,77
4	Light-loamy grey soils	3	414,6-531,40	472,68±33,76	58,40	12,36
5	Meadow-brown sabulous soils	5	629,35-749,40	671,42±20,73	46,44	6,92
6	Grey-brown highly skeletal sabulous soils	3	621,95-654,10	636,77±9,38	16,22	2,55
7	Overflow-marsh soils	3	274,65-359,80	314,74±11,90	29,17	9,27
8	Ringe-uneven half-durable sands	4	354,4-369,90	358,40±3,83	7,67	2,14
9	Sands desert-steppe durable	5	404,6-429,50	410,55±4,82	10,79	2,63
10	Meadow heavy sabulous saline soils	4	289,9-364,80	331±16,60	33,19	10,03

Morphological horizon of sands is characterized by weakly separated genetic horizons, ashy structure, and fluffy consistency. There is seen an equal element content in sands down the horizon. Total manganese content in sands varies from 354.4 to 369.90 mg/kg, average concentration equal to 358.40 mg/kg, variation coefficient is 2.14 mg/kg.

In the horizon of marshy soil total manganese content varies from 274.65 to 359.80 mg/kg, variation coefficient – 9.27%, average concentration – 314.174 mg/kg. Correlation connection with humus is positive with mean power ($r=0.74$).

Total manganese content in meadow heavy sabulous saline soils varies from 289.9 to 364.80 mg/kg, average concentration 33 mg/kg. Concentration of manganese is in direct dependence of humus ($r=0.86$).

The concentration of moving forms of manganese in soils varies between 8.9-149 mg/kg; the average concentration of this form is 47.26 mg/kg. Mobile manganese in the soil horizon distributes ambiguously, however, large differences between horizons is not seen. It should be noted that the higher concentration of moving manganese in lower horizons are situated in most studied soils. The lowest values of the average content of mobile forms of manganese are found in the ringe-uneven half-durable sands– 26.15 mg/kg and in meadow heavy sabulous saline soils – 24.02 mg/kg. The highest mobile forms manganese content is typical for marshy soils with concentration of 124.33 mg/kg and for the meadow-brown light-loamy

soils with concentration of 51.10 mg/kg. Correlation between the mobile form of the manganese and its gross content in most cases is inverted (r – from -0.33 to -0.99), humus (r – from -0.34 to -0.94) – reverse to the weak and average power. In most soils, the correlation between mobile forms manganese and pH medium is positive to the strong and average power (r – from 0.58 to 0.94). Between carbonates and manganese mobile forms a positive relationship of strong power is visible only in the meadow heavy sabulous saline soils ($r=0.89$). The content of mobile forms manganese has a reliable direct connection of strong importance with silt fraction in the light-loamy grey soils $r=0.93$, grey-brown highly skeletal sabulous soils ($r = -0.89$).

According to «Classification of soils on the content and the degree of pollution by moving forms of heavy metal compounds» [5], based on detected concentration of mobile form of manganese in soils, the Alakol hollow can be considered as unpolluted soils with an average content of this metal.

Resume:

1. There were conducted researches on determination of total manganese concentration and its mobile forms in parent rock materials and soils of Alakol hollow, and were evaluated ecologically and geochemically.

2. In most cases the content and distribution of the total manganese content in soils and correlation dependence from the clay fraction, carbonates, pH of medium has reversed character or has a connection of weak power.

3. In the exchangeable bank of manganese compounds in the soil the share of mobile forms is 10.5% of the total content.

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АЛАКӨЛ ОЙЫСЫНЫҢ ТОПЫРАҚ ҚҰРАМЫНДАҒЫ МАРГАНЕЦ

Аннотация. Алакөл ойысының топырақтары зерттелген. Құба, шалғынды-құба, сұр-құба, сұр топырақ, шалғынды сортаң топырақ, төбешікті-тізбекті құмдар, батпақты топырақтардың физикалық-химиялық қасиеттері анықталған. Сонымен бірге мырыштың (Mn) жалпы және қозғалмалы концентрациясы қарастырылған. Элементтер концентрациясын анықтау топырақ кескіні бойынша жүргізілді. Мырыштың (Mn) жалпы және қозғалмалы концентрациясы атомды-абсорбциондық әдіспен анықталды. Алынған мәліметтер Microsoft Excel бағдарламасы көмегімен Н.А. Плохинский бойынша статистикалық өңдеу жүргізілді. Қарастырылып отырған элемент мөлшерінің деңгейіне баға беріліп, топырақ кескінінде таралу ерекшеліктері қарастырылған. Мырыштың топырақтың физикалық-химиялық көрсеткіштеріне байланысты корреляциялық тәуелділік коэффициенттері есептелді. Алакөл ойысының топырақтарында және аналық тау жыныстарында мырыштың жалпы және қозғалмалы мөлшерін анықтау зерттеу жұмыстары жүргізіп, экологиялық-химиялық баға берілді. Топырақтағы жалпы мырыштың мөлшері мен таралуы анықталып лайлы фракция, карбонаттар, pH ортасына байланысты корреляциялық тәуелділік анықталды. Топырақтағы мырыш қосылыстарының қозғалмалы қорындағы қозғалмалы формаға жалпы мөлшерден 10,5% тиесілі екендігі анықталды. Мырыштың мөлшері мен жинақталуы бойынша алынған мәліметтер Mn Алакөл ойысындағы шөл және шөлейт топырақтарында таралу заңдылықтарын көрсетеді. Топырақтардың негізгі физикалық-химиялық қасиеттері анықталып, мырыштың жалпы және қозғалмалы мөлшеріне сипаттама берілді.

Түйін сөздері: топырақ, химиялық элементтер, ауыр металдар, мырыш, жалпы мөлшері, қозғалмалы формасы, фондық мөлшері.

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СОДЕРЖАНИЕ МАРГАНЦА В ПОЧВАХ АЛАКОЛЬСКОЙ ВПАДИНЫ

Аннотация. Исследованы почвы Алакольской впадины. Рассмотрены физико-химические свойства бурых, лугово-бурых и серо-бурых почвы, сероземов, солончаков луговые, песков грядово-бугристых полу-закрепленных, плавнево-болотные (пойменные болотные) почв, также содержание валовой и концентрация подвижной формы марганца (Mn). Изучение концентрации элементов проводилось по профилям почв. Содержание валового и концентрацию подвижной формы Mn в почвах определяли атомно-абсорбционным методом. Проведена статистическая обработка полученных данных проводилась по Н.А. Плехинскому с использованием программы Microsoft Excel. Дана оценка уровня концентраций исследуемого элемента, рассмотрен характер его внутрипрофильного распределения. Рассчитаны коэффициенты корреляционной зависимости содержания марганца от показателей физико-химических свойств почв. Проведены исследования по определению содержания валового марганца и его обменной формы в почвообразующих породах и почвах Алакольской впадины, дана их эколого-геохимическая оценка. Определено содержание и распределение валового марганца в почвах и корреляционная зависимость от илстой фракции, карбонатов, pH среды. Выявлено, что в мобильном фонде соединений марганца в почвах на долю подвижной формы приходится – 10,5%, от валового содержания. Полученные сведения по содержанию и накоплению марганца отражают закономерности распределения Mn в полупустынных и пустынных почвах Алакольской впадины. Определены их основные физико-химические свойства, валовое содержание и обменная (подвижная) форма Mn.

Ключевые слова: почва, химические элементы, тяжелые металлы, марганец, валовое содержание, обменная форма, фоновое содержание.

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